REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)

2. REPORT DATE
December 5, 1996

3. REPORT TYPE AND DATES COVERED
Final: 1 OCT 1988 through 31 AUG 1996

4. TITLE AND SUBTITLE
Numerical Studies of Flow Past Isolated Seamounts

5. FUNDING NUMBERS
N00014-89-J-1106

6. AUTHOR(S)
David C. Chapman and Dale B. Haidvogel

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Woods Hole Oceanographic Institution
360 Woods Hole Road
Woods Hole, MA 02543-1541

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Department of the Navy
Office of Naval Research
Resident Representative
496 Summer St., Room 103
Boston, MA 02210-2109

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Final Report attached

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)
see attached

19961212 036

14. SUBJECT TERMS
seamount; Taylor caps; Fieberling Guyot; steep topography; internal lee waves; seamount-trapped waves; mean flow generation; dirunal tide; numerical modeling

15. NUMBER OF PAGES
3

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
unclassified	unclassified	unclassified	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

Final Report for ONR grant N00014-89-J-1106

''Numerical Studies of Flow Past Isolated Seamounts''

Principal Investigators: David C. Chapman, Woods Hole Oceanographic Institution and
Dale B. Haidvogel, Rutgers University

Our long-range goal was to understand the influence of tall and/or steep topographic features on the ocean circulation. Of particular interest was the occurrence of systematic processes such as upwelling, mixing, eddy shedding, mean flow generation, and the trapping of energy and/or water parcels in the neighborhood of such features. Our approach was to use a sigma-coordinate primitive-equation numerical model to explore the flow past a tall isolated seamount under a variety of conditions, and with varying degrees of realism.

We began with several idealized studies of flow past a tall isolated seamount. A number of technical issues were explored in order to better understand the model performance and limitations, as well as to provide insight into model improvements (Beckmann and Haidvogel, 1993). We studied eddy shedding and the formation of regions of trapped fluid, called Taylor caps, resulting from steady flow past a tall, Gaussian-shaped seamount in a stratified ocean (Chapman and Haidvogel, 1992). We quantified the occurrence of Taylor caps for various inflow speeds and seamount heights. We then investigated the generation of internal lee waves over this same idealized seamount, showing that these lee waves result from the local nonlinear acceleration of flow around the seamount, and that they may be important for local mixing (Chapman and Haidvogel, 1993). We also studied the excitation of seamount-trapped waves caused by weak ambient tidal oscillations (Haidvogel et al., 1993). This work confirmed the amplification of these waves under certain conditions and showed that a rectified mean anti-cyclonic flow is generated as well, consistent with observations near Fieberling Guyot. Finally, we explored the combined effects of weak oscillatory tides and steady inflow, and found that the response is basically the superposition of the two separate responses (Goldner and Chapman, 1996). Steady flow tends to remove water parcels from the seamount, while tidal flow tends to mix fluid vertically.

The effects of flow past a tall isolated seamount on the process of deep convection caused by atmospheric cooling were studied in an idealized setting (Alverson, 1995; Alverson and Owens, 1996; Alverson, 1996). These studies revealed that the trapping of fluid within a Taylor cap enhances the effects of convection, leading to deeper penetration. Furthermore, the flow around the Taylor cap apparently suppresses baroclinic instability of the convecting chimney.

A very high-resolution simulation was performed to explore tidally forced flows near Fieberling Guyot. Three major characteristics of the flow observed at Fieberling Guyot were reproduced both qualitatively and quantitatively: diurnal currents reach about

20 cm/sec, a 20-fold amplification relative to the tidal flow away from the seamount; the time-mean anticyclonic flow speeds are close to the observed 10 cm/sec maximum azimuthal velocity; and the spatial structure of this vortex shows a maximum at about 6 km radius between 400 and 600 m depth, clearly lifted off the bottom. The time-mean flows were found to be maintained by diurnal waves of mixed type: the net motion shows characteristics of both bottom-intensified seamount trapped waves and vertically propagating vortex trapped waves. While the former are mainly responsible for setting up a time-mean anticyclonic flow along the upper flanks at the bottom, the latter are needed to redistribute the momentum and time-mean density, thereby reproducing the observed structure with a flow maximum off the bottom.

Resulting Publications:

Alverson, K., 1995. Topographic preconditioning of open ocean deep convection, Ph.D. Thesis, *MIT/WHOI Technical Report*, 95-26.

Alverson, K. and W.B. Owens, 1996. Topographic preconditioning of open ocean deep convection. Journal of Physical Oceanography, in press.

Alverson, K., 1996. Mechanisms for lateral exchange with oceanic convection sites. Journal of Physical Oceanography, submitted.

Beckmann, A., and D.B. Haidvogel, 1993. Numerical simulation of flow around a tall isolated seamount. Part I: Problem formulation and model accuracy, . Journal of Physical Oceanography, **23**, 1736-1753.

Beckmann, A., and D.B. Haidvogel, 1996. Numerical simulation of flow at Fieberling Guyot. *Journal of Geophysical Research*, accepted.

Chapman, D.C. and D.B. Haidvogel, 1992. Formation of Taylor caps over a tall isolated seamount in a stratified ocean. *Geophys. Astrophys. Fluid Dyn.*, **64**, 31-65.

Chapman, D.C. and D.B. Haidvogel, 1993. Generation of internal lee waves trapped over a tall isolated seamount. *Geophys. Astrophys. Fluid Dyn.*, 69, 33-54.

Goldner, D.R. and D.C. Chapman, 1996. Flow and particle motion induced above a tall seamount by steady and tidal background currents, *Deep-Sea Research*, in press.

Haidvogel, D.B., A. Beckmann, D.C. Chapman and R-Q. Lin, 1993. Numerical simulation of flow around a tall isolated seamount, Part II: Resonant generation of trapped waves. . *Journal of Physical Oceanography*, **23**, 2373-2391.